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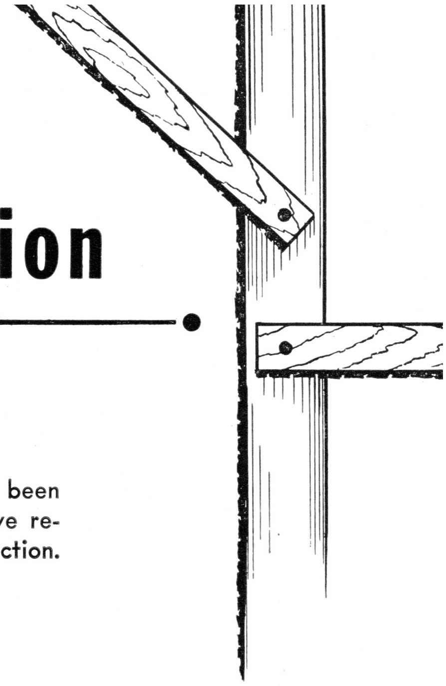

Progress in Pole Construction

Some of the older and poorly constructed pole framed buildings have been targets of criticism. New developments and techniques, however, have resulted in improvements which increase the advantages of pole construction.

by R. A. Norton

POLE FRAMED buildings have a wide reputation as a low-cost type of construction. Some folks have looked down on them—interpreting low cost to mean "cheap" or "flimsy" rather than economical. Textbooks on farm structures, too, have often dismissed pole framed buildings as suitable only for open sheds, hay-storage structures, pasture shades and the like.

This attitude may have been justified by the performance of some of the structures built earlier or those built without following good construction practices. More recently, however, a number of developments and techniques have largely removed the causes for criticisms. Enhancing the natural advantages of pole framed construction are such developments as:

- Commercial pressure preservative treatment of poles;
- Improved nails and other timber fasteners;
- Better insulating materials and ventilating equipment;
- More information on improved construction practices;
- Mechanical methods of packaging and handling hay and bedding materials;
- Use of loose-housing techniques for handling dairy cattle;
- Mechanical equipment for removing manure.

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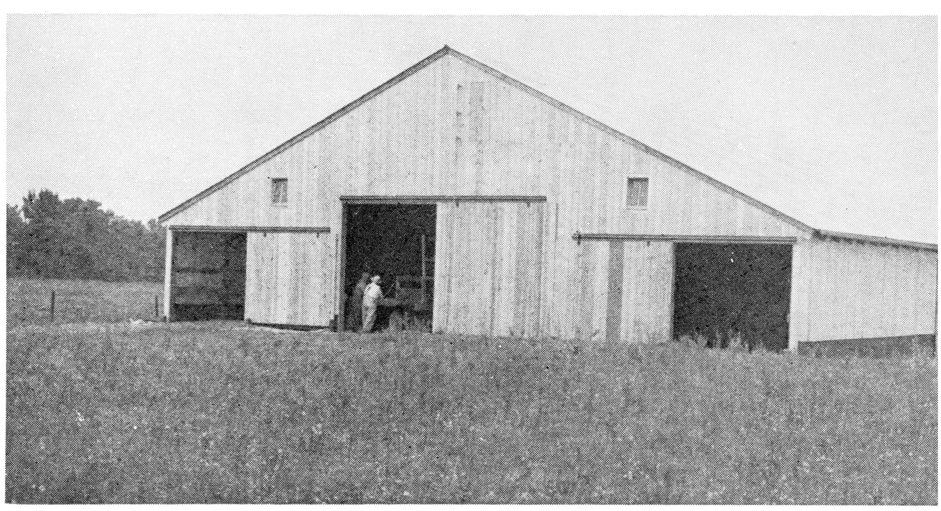
All in all, new developments and techniques combine to offer a number of advantages for pole framed construction of farm buildings. Let's look at some of them:

Adaptability: Pole framed buildings are readily adaptable to many functions. Interiors are relatively open, unobstructed and subject to easy rearrangement — particularly those with trussed roofs. They also retain the simplicity and cost advantages always inherent in them.

Cost: When you construct a farm building, your main concerns are probably purpose, suitability, performance, durability and cost. We've already mentioned that pole framed construction is generally less costly than other methods. But if there are additional ways of reducing the cost of the structure without reducing its suitability, durability or performance, you're that much further ahead. This is what we call gaining "efficiency" in construction and can be achieved in several ways:

1. Increasing strength without raising cost or at lower cost;
2. Reducing costs of materials (a) by using less material or (b) by using lower-cost fastenings;
3. Cutting costs of assembly or erection (a) by reducing the degree of skill required, (b) by reducing the amount of time needed or (c) by reducing the difficulty of the tasks;
4. Balancing the strength of the structural members.



This lowering of cost, without sacrificing other desirable features, has been the objective of a study of pole framed construction just completed by agricultural engineers at Iowa State College. Here are some of the results and conclusions from that study:

Over-all Design . . .

Except for the poles themselves, the structural members used in pole framed construction can be selected by methods well known to all structural designers and be incorporated into plans for pole framed construction. Such members include rafters, trusses (where desired for clear spans), sub-purlins, purlins, girts and girders. The large drawing illustrates the framing of a pole framed structure and identifies these members showing their relative positions.

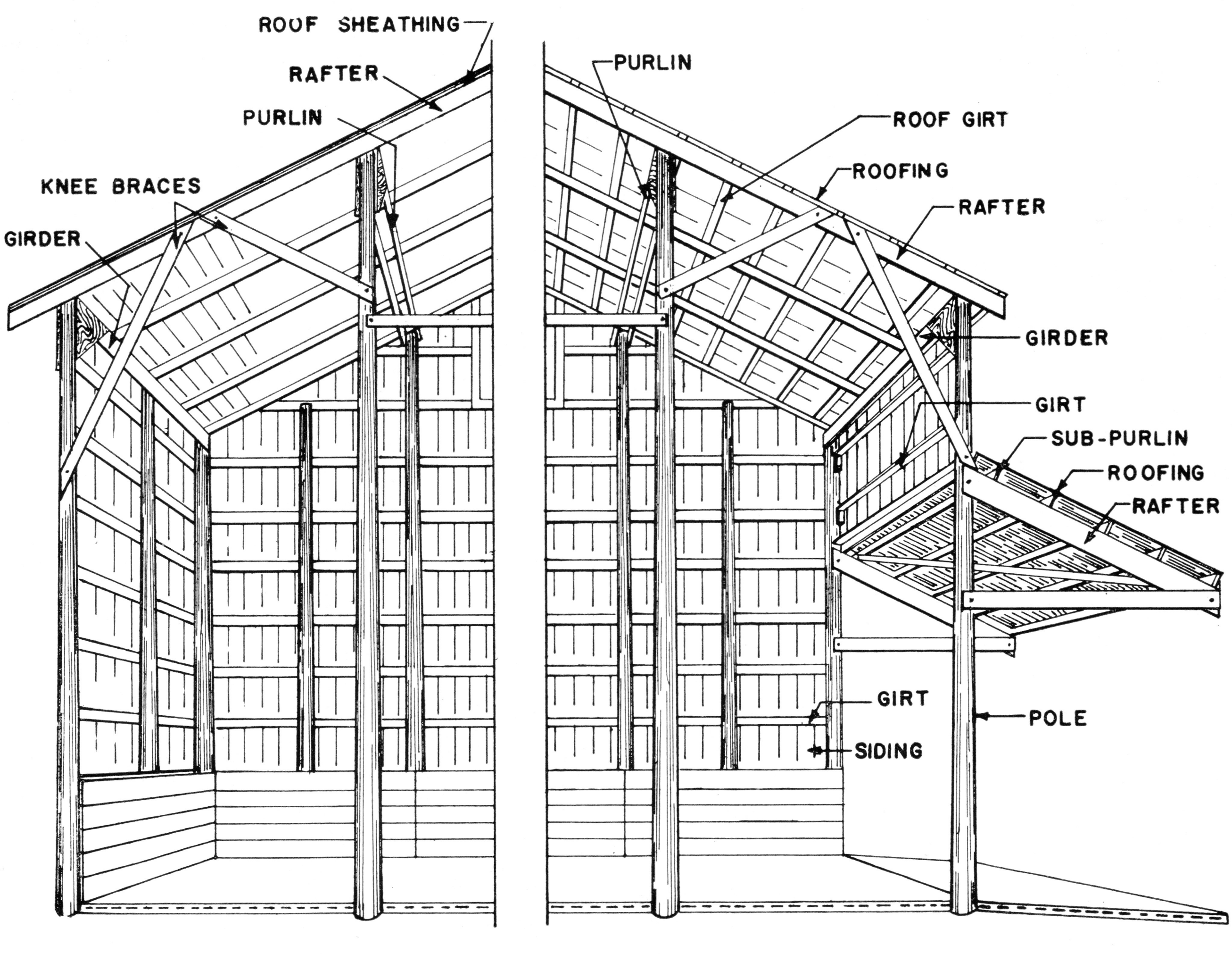
In the past, very little was known about the strength properties of the poles. Larger sizes than necessary have often been used. With the aid of methods developed in our study, however, experienced designers of farm structures can now choose economical poles, according to need, from those commonly available at lumber yards in the Midwest. Concrete pads under most poles are now being incorporated into designs. This provides a greater bearing area for the poles and prevents settling. The main problem remaining then is the strength needed for the joints between various members.

Almost all pole framed buildings are of single-story design, so there are no floor loads to consider. The usually low-pitched roof, however, leads to greater snow loads than are experienced with the steeper gable, gambrel or arch roofs. We recommend construction to support a snow load of about 15 pounds per square foot in southern Iowa to about 20 pounds in northern Iowa. The dead loads from roofing and the roof deck structure act in about the same manner as snow loads but will seldom exceed 3 pounds per square foot.

It is not economically feasible to design farm buildings to withstand tornadoes. But it's common practice to design midwestern farm buildings to resist winds that would develop a pressure of about 30 pounds on each square foot of the windward side of a vertical surface. This is equivalent to a wind velocity of about 108 miles an hour. The wind velocities you hear reported are usually read at a height of 30 feet. Velocities are lower below this height because of friction between air and ground. Since pole framed structures rarely reach a height of 30 feet, they would seldom be subject to such severe pressure.

Joints . . .

Roofing material or sheathing is nailed to roof girts or to sub-purlins that are supported by the raf-



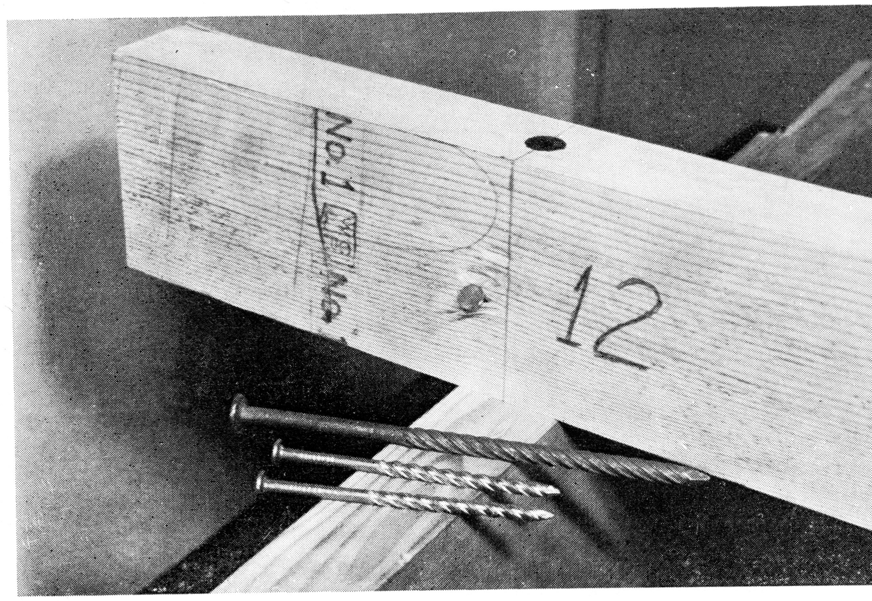
ters. Rafters may be attached directly at the tops of poles, or they may be supported between pole locations by purlins or girders. These, in turn, are attached near the tops of the poles. Joints between the purlins or girders and the poles must be braced to resist twisting or racking of the building frame by horizontal wind forces.

Fastening of roof materials or sheathing for pole framed buildings is no different than that for other buildings. Satisfactory attachments between intermediate rafters or trusses and purlins or girders between poles may be made by using metal framing anchors or nailing blocks cut to fit from dimension lumber. These joints also, as used in pole framed buildings, don't differ materially from similar joints in conventional structures.

The method of joining framing members, however, becomes critical where the area for attachment is small; for example, where sub-purlins attach to rafters and where dimension members meet or cross poles at right angles. Here there's only limited contact between members to be joined. And our efforts to devise improved methods of attachment were concentrated on these situations.

Sub-Purlin to Rafter Joints: Roofs on many farm buildings are designed so that the roofing material or sheathing is supported by light framing lumber, spaced about 2 feet apart and running the same direction as the ridge. Where these members are supported on rafters 4 feet or less apart, they're not designed as structural members and are laid on flatwise as part of the covering material. In this situation, they're called roof girts. Simple items of hardware, even common nails, provide adequate attachment to the rafters.

Sometimes the rafters are more widely separated. Then it's necessary to design beams to support the roofing material or sheathing. These beams now become structural members, are placed on edge and are called sub-purlins. Placing intersecting dimension members such as sub-purlins and rafters edge-to-edge provides little bearing area. And the method of attaching them calls for careful attention.



This sub-purlin to rafter joint, using one 6-inch hardened steel screw-shank nail and two 3½-inch regular steel screw-shank nails toenailed through the sub-purlin into the rafters, was the strongest among the 13 types of joints tested.

Causes of failure: Joints between sub-purlins and rafters may be subject to failure from three different causes: (1) crushing of surface fibers of joined members; (2) twisting effect of that part of the snow or roofing load which acts parallel to the roof surface and tends to tip sub-purlins on their sides—a force that may be enough to start the withdrawal of a fastener; (3) action of the wind on low-pitched roofs — particularly wind blowing toward the unwalled side of an open-front shelter. This develops forces which tend to separate sub-purlins and rafters. Analysis of these three effects indicates that the wind force tending to separate the members is the most critical one under Iowa conditions.

Recommended joint: We tested 13 joints or parts of joints to select a combination giving the greatest resistance to direct separation. Fasteners tested included timber ties with various nailing patterns, metal ties, metal framing anchors, and various sizes and types of common and "deformed" nails. Of these, two joints made up with screw-shank and ring-shank nails proved superior to all others—sustaining loads twice as great as might be expected in a severe windstorm.

Joints made up with screw-shank nails (see photo) provided consistently greater resistance than those made up similarly with ring-shank nails. To use the type of joint shown in the photo, you may find it necessary to pre-bore holes through the 4-inch dimension of the sub-purlin to avoid splitting. If so, use a twist drill of about two-thirds the diameter of the nail shank.

Purlin-to-Pole Joints: There's no essential difference between the joints by which purlins are attached to poles or by which girders are attached to poles. The differences between the two kinds of dimension members lie only in their relative positions in the structure and in the functions they perform.

With poles spaced about 16 feet apart, both directions, in a building, the joints between purlins and the poles that support them may commonly be called on to support combined snow and roofing loads of 4,500 to 6,000 pounds. Farm building designers consider it desirable to provide joints that can resist at least double the normal load. This is to withstand unexpected loads that may occur only two or three times during the life of the building or to compensate for an occasional defective joint or structural member.

On this basis, we decided that a satisfactory joint should hold test loads of 9,000-12,000 pounds without sliding more than ½ inch down the poles. Further, they should permit assembly by a workman on a ladder without unreasonable time and effort.

Testing: Searching for such a joint, we tested 15 *types* of joints. Some were made up with improvised hardware, some with nails of various types and sizes, some with bolts and some with commercially produced hardware such as split-ring and toothed-ring timber connectors and single-curve spike grids. Preliminary tests showed that several kinds of joints could be made with ample strengths—even beyond the range for which other joints and members of pole framed buildings are designed. But the stronger joints were difficult to apply on standing poles.

Some of the joints made up with common nails neared sufficient strength and were also easy to make. But, as loads were increased, paired dimension members tended to spread away from the poles. As nails started to withdraw, the strength of the joints dropped rapidly. Still needed: a simple method of reinforcing the nailed joints to prevent dimension members from spreading.

Sufficient strength at reasonable cost: We tested various methods of holding the dimension members tightly against the poles. These included pairs of bolted bands, twisted strands of wire and, finally, commercial steel strapping. Additional testing of purlin-to-pole joints using six 50-penny common nails per side and banded with two stainless steel straps (see sketch) showed that these joints could support average loads of over 14,000 pounds each. The sketch shows dimension members continuous across the face of the pole, but similar strength can be developed with butt-joined dimension members.

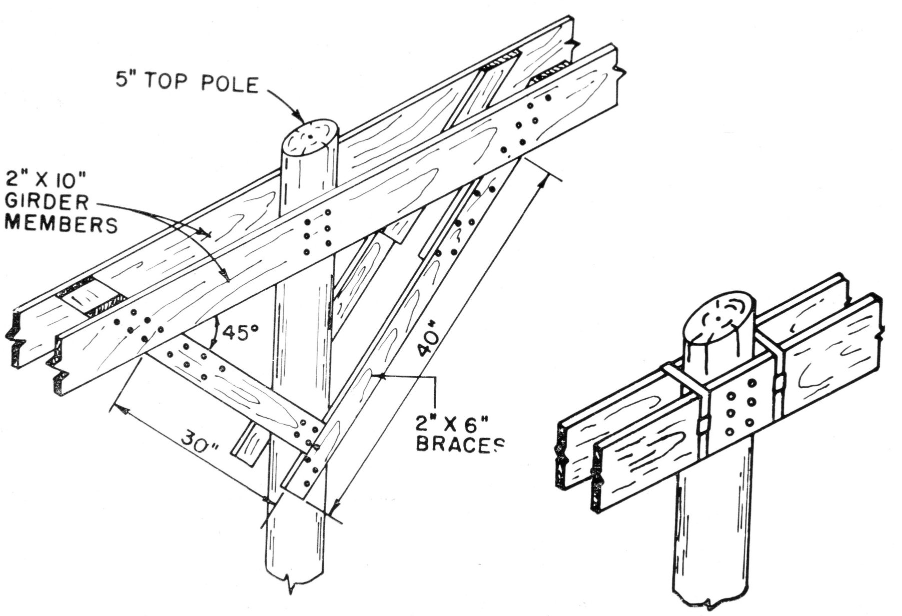
Cost of the stainless steel strapping for banding each purlin-to-pole joint in a pole framed structure is less than 30 cents. For an average-size barn, say 50 by 60 feet, the material wouldn't cost more than \$7-\$10, and the time needed to apply shouldn't exceed 1½ to 2 hours.

Wind Bracing: There's considerable variation among the plans distributed by several industrial concerns producing building materials as to recommended methods of knee-bracing pole framed buildings against wind loads. This variation is also present among buildings erected by contractors under license by various agencies. Variations in locations could account for some of this. But the so-called standard plans definitely aren't uniform and frequently don't state the limitations of locale to which they apply.

To gain more specific information, we tested knee-bracing for purlin-to-pole joints assembled according to the methods most often seen in pole framed buildings and in the so-called standard plans. These tests indicated that most couldn't be depended on to resist the horizontal force of winds more than 90 miles per hour. This velocity, however, is rather commonly experienced, if only briefly, in Iowa during thunderstorms. While such winds might not cause failure in the building, they could cause weakening—making the building more susceptible to future damage.

Improved methods: In testing types of knee-bracing, we found much variation in resistance to the twisting or racking forces of wind. A notable point of weakness in conventional bracing methods was where scab boards or bearing plates were placed between the poles and the lower ends of diagonal braces to bring these members into proper position for nailing. As loads came onto these joints, scab boards would split lengthwise, and the resistance of the joints dropped rapidly.

The knee brace we found most effective (see sketch) doesn't use a scab board but resisted loads equivalent to wind velocities of 130 miles per hour or more. At the same time, the joint requires about 20 percent less lumber in diagonal members and attachments than those most commonly used to date.



LEFT: This improved scheme for bracing interior joints in pole framed buildings increases strength by half and also reduces lumber needed. RIGHT: Purlin-to-pole or girder-to-pole joint using 12, 50-penny common nails and stainless steel strapping. The joint is strong and requires less work than similar joints used in pole construction.

Summing Up . . .

The findings of this research and the development of the methods and techniques outlined in this article will, we believe, add to the advantages and economies of pole framed construction for farm buildings. Application of these findings both in the design and construction of pole framed buildings should increase the durability and performance of such structures at lower costs.